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INFLUENCE OF *PSOROPTES OVIS* ON THE ENERGY METABOLISM OF HEIFER CALVES*

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ABSTRACT

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To determine the effect of *Psoroptes ovis* on the energy metabolism of heifers, 32 calves were randomly assigned to four treatments in a 2 × 2 factorial arrangement. Calves were fed the same diet at two intake levels, high or low, and were either infested or were not infested with *P. ovis* mites. Calves were housed in antigrooming stanchions. Body composition was determined by urea dilution on Days 0 and 63. Ration digestibility was determined on fecal grab samples using acid-insoluble ash as a marker.

Infested calves had developed a severe *P. ovis* infestation 7 weeks following exposure and had significantly lower daily gain, gain:feed, and energy retention and higher serum glutamic-oxaloacetic transaminase than control calves. *P. ovis* infestation increased the maintenance energy requirement of calves by >50% (79 *vs.* 123 kcal of net energy kg^{-1} body $wt^{.75}$). For each 10% increase in the body surface affected by *P. ovis*, maintenance energy requirement increased 0.5 mcal day^{-1}.

INTRODUCTION

Psoroptic mange of cattle caused by the mite *Psoroptes ovis* (Hering) has a significant economic impact on the beef cattle industry. Studies have shown that *P. ovis* infestation can significantly reduce the average daily gain and feed efficiency of cattle; however, the reduction in daily gain does not occur until the infestation covers >15% of the calves body surface (Fisher and Wright, 1981; Cole et al., 1984). It is not clear how the severity of infestation affects feed efficiency and energy metabolism; however, heavy infestations may increase the maintenance energy requirement. With minor infesta-

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tions, the maintenance energy requirement is either not affected or is compensated by an increased feed intake (Cole et al., 1984).

This study was conducted to determine the influence of *P. ovis* infestation on the feed efficiency and energy metabolism of heifer calves.

MATERIALS AND METHODS

Animals and facilities

Thirty-two Hereford heifer calves, averaging 144 kg in weight, were purchased at a local auction. Upon arrival at the USDA Livestock Insects Laboratory at Kerrville, TX, the calves were weighed, injected with ivermectin (Ivermectin injectable formula, Merck and Co. Inc., Rahway, NJ 07065), vaccinated for *Clostridium chauvoei*, *C. novyi*, *C. septicum* and *C. sordelli* (Franklin 4-way, Franklin Laboratories, Denver, CO 80222) and were ear tagged. Calves were fed a 70% concentrate diet (Table I) at 2.0% of body weight. Following a 4-week adaptation period, calves were weighed and placed in antigrooming stanchions in the research barn. Calves were blocked by weight and randomly assigned to four treatments in a 2 × 2 factorial arrangement of treatments, and were fed the 70% concentrate diet at either 1.25 (low) or 2.5% (high) of body weight until the end of the trial (Day 63). These intakes were calculated to be 1× and 2× the maintenance energy requirement (NRC, 1984). Feed was weighed daily and feed refusals were de-

TABLE I

Composition of experimental diet

Item	International feed number	Amount[a]
Bermuda grass hay, ground	1-00-703	30.4
Oats	4-03-309	22.8
Cottonseed meal	5-01-621	11.4
Corn, crimped	4-02-931	23.3
Salt	6-04-152	1.0
Bone meal	6-00-400	0.89
Molasses	4-04-696	10.1
Vitamin A	7-05-143	5000 IU kg^{-1}
Calculated chemical component[b]		
Crude protein		12.4
Metabolizable energy		2.54 mcal kg^{-1}
Net energy — maintenance		1.61 mcal kg^{-1}
Net energy — gain		0.89 mcal kg^{-1}

[a] Percent, dry matter basis, unless shown.
[b] Calculated from NRC (1984).

termined at the end of each week. Half of the calves were infested on the midline of the withers (infested) with ~1000 *P. ovis* mites taken from a donor animal. The remaining calves were not infested (control). Rectal temperatures were recorded and calves were scored and sampled for mites using the technique of Guillot and Meleny (1982) on Days 28, 49 and 62 post-exposure.

Body composition determinations

Calves were weighed following an 18-h period without feed and water on Days 1 and 63. Body composition was determined using the urea-dilution technique of Preston and Koch (1973). Approximately 125 ml of a 20% urea, 0.9% NaCl solution was infused through a catheter into the right jugular vein over a 2-min period. A second blood sample was taken 12 min later from the left jugular vein. Body urea space was calculated from the formula:

% urea space = [(ml infused * urea − N concentration of solution)/change in serum urea-N] /kg empty body weight

Total body water was determined from urea space and body weight using the equation of Hammond et al. (1984); body fat and protein were calculated from body water by the equations of Gil et al. (1970). Total body energy was determined by assuming a caloric value of 9.5 kcal g^{-1} for fat and 5.45 kcal g^{-1} for protein (NRC, 1984). The difference in final (Day 63) and initial (Day 1) body energy was total body energy retention.

Digestibility determinations

Fecal grab samples were obtained at the start and end of the trial. Dry matter digestibilities (DMD) were determined by the equation:

DMD = 100 − [100 × (% marker in feed/% marker in feces)]

using acid-insoluble ash as an internal marker (Van Keulen and Young, 1977).

Serum analysis

Serum was collected at the start and end of the trial and analyzed for free fatty acids (Smith, 1975), urea-N (Marsh et al., 1965) and for glutamic-oxaloacetic transaminase (GOT) using commercially available kits (Sigma Chemical Co., St. Louis, MO).

Statistical analysis

Data were analyzed by analysis of variance as a 2 × 2 factorial arrangement of treatments using the general linear models procedure of SAS (SAS, 1979). Least squares linear regression lines were calculated to determine the maintenance energy requirement of infested and control calves (Snedecor and Cochran, 1971).

RESULTS

Infested calves had developed severe psoroptic mange 7 weeks following infestation (Table II). No calves, however, developed a fever. Feed intake level did not affect either the percentage of body surface area affected or the number of mites isolated from skin scrapings. On Week 9 the infestation

TABLE II

Extent of *P. ovis* infestation in infested calves (mean ± standard error)

Week	Feed intake	
	Low	High
% of body surface affected		
4	5.9 ± 1.4	6.4 ± 0.9
7	47.0 ± 9.9	57.1 ± 3.3
9	85.1 ± 9.4	98.6 ± 5.5
Total number of mites		
4	162 ± 169	318 ± 246
7	428 ± 359	775 ± 429
9	592 ± 828	988 ± 409

TABLE III

Performance of calves infested with *P. ovis* for 63 days

Treatment[e]	Daily gain (kg)	Daily feed intake (kg)[f]	Gain:feed ratio ($g\ kg^{-1}$)[g]	Total energy retention (mcal)
1.25%				
Control	-0.07[a]	1.84[a]	-38.0[a]	-10[a]
Infested	-0.30[b]	1.80[a]	-167.1[b]	-45[b]
2.5%				
Control	0.46[c]	3.56[b]	128.6[c]	80[c]
Infested	0.06[a]	3.40[b]	16.5[d]	9[a]
SEM[h]	0.05	0.16	20.4	8.6

[a,b,c,d] Means in each column with different letters are significantly different, $P < 0.05$.
[e] Calves were fed daily at indicated % of initial weight.
[f] Dry matter basis.
[g] Grams total weight gain kg^{-1} total feed dry matter intake.
[h] Standard error of the mean.

had become so severe that three calves died. The trial was terminated at this time.

Initial body weight (Table III) and body composition were similar for all treatment groups. Calves had an initial body composition of 68% water, 10% fat and 17% protein (% of empty body weight) and an initial body energy content of 242 mcal. High feed-intake control calves had a slight increase in body fat percentage during the trial (10.1 to 12.2%) while low feed-intake infested calves had a slight decrease in body fat percentage (10 to 8.6%). These differences were not statistically significant. Feed refusals were small in all groups. Daily weight gain and gain:feed ratio were significantly reduced by *P. ovis* infestation at both feed intake levels (Table III).

Dry matter digestibilities

Dry matter digestibility was not significantly affected by *P. ovis* infestation or level of feed intake (Table IV). However, calves infested with *P. ovis* tended to have lower dry matter digestibilities than control calves.

TABLE IV

Feed dry matter digestion by control and infested calves

Feeding rate[a]	Dry matter digestibility, %	
	Initial	Final
1.25%		
Control	59.6	65.1
Infested	60.2	63.7
2.5%		
Control	60.9	65.0
Infested	60.5	62.5
SEM[b]	1.6	1.8

[a]Calves were fed daily at indicated % of body weight.
[b]Standard error of the mean.

Energy retention

The relationship between body energy retention and intake of metabolizable energy (ME = feed energy − (fecal + urine + methane energy) for control and infested calves is presented in Fig. 1. Normally, these regression lines would not be extrapolated through 0 energy retention (i.e. maintenance energy requirement) since the slope of the lines is different

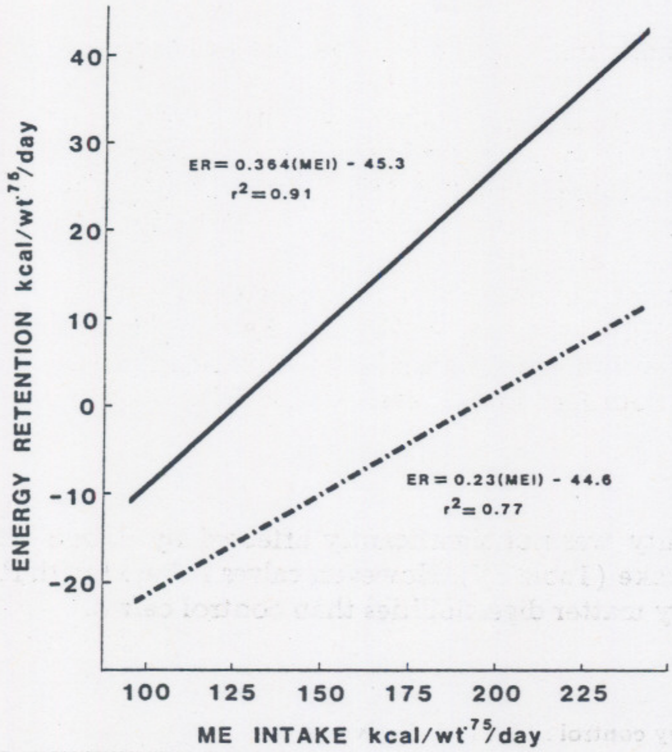

Fig. 1. Relationship between energy intake and energy retention in control (solid line) and *P. ovis*-infested (dashed line) calves.

above and below maintenance (Blaxter, 1962). However, in this experiment the energy retention values for the low feed-intake control and high feed-intake infested groups are so near 0 that little error would occur by extrapolating through 0 energy gain. The calculated maintenance energy requirement for control calves was 124.5 kcal ME day^{-1} kg^{-1} wt$^{.75}$ and for infested calves was 193.9 kcal ME day^{-1} kg^{-1} wt$^{.75}$; a 55% increase. When converted to kcal of net energy (NE = ME − heat increment) required per kg of metabolic body weight (MBW = wt$^{.75}$), the maintenance energy requirements were 78.8 and 122.7 kcal kg^{-1} MBW for control and infested calves, respectively.

To determine the influence of the severity of *P. ovis* infestation on energy retention a least squares linear regression line was calculated using the individual data from control calves to predict energy retention from metabolizable energy intake. The equation was:

$$ER = 0.364\,(MEI) - 45.3\ (r^2 = 0.91)$$

in which ER is total energy retention in kcal kg^{-1} MBW day^{-1} and MEI is metabolizable energy intake in kcal kg^{-1} MBW day^{-1}. The actual energy retention of infested calves was divided by the predicted gain to obtain a ratio which corrected for differences in energy intake. These ratios were then plotted against the extent of *P. ovis* infestation at Week 7 (Fig. 2). Week 7 data were used because it was near the midpoint of the *P. ovis* infestation

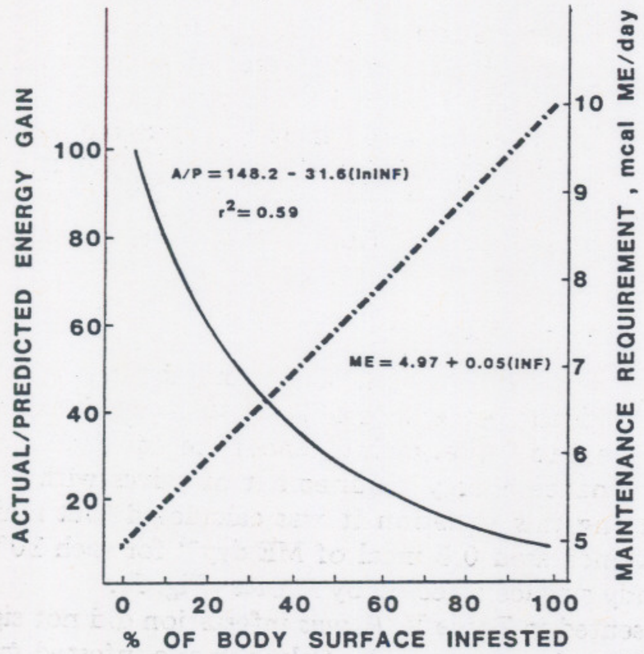

Fig. 2. Influence of severity of *P. ovis* infestation at Week 7 on actual/predicted energy retention (solid line) and calculated maintenance energy requirements, mcal ME day^{-1} (dashed line).

TABLE V

Serum urea-N, free fatty acids and GOT of control and infested calves

	Low intake		High intake		SEM[b]
	Control[a]	Inf[a]	Control	Inf	
Urea-nitrogen, mg 100 ml^{-1}					
Initial	9.2[d]	9.7[d]	6.8[c]	7.2[c]	0.47
Final	11.4[d]	10.6[d]	7.7[c]	7.4[c]	0.51
Free fatty acids, micromoles l^{-1}					
Initial	418	510	316	418	61
Final	561	486	554	392	70
GOT[e], microunits ml^{-1}					
Final	190[c]	369[d]	202[c]	433[d]	47

[a]Control = noninfested, Inf = infested with *P. ovis*.
[b]Standard error of the mean.
[c,d]Values in same row with different letters are significantly different, $P < 0.05$.
[e]GOT = glutamic-oxaloacetic transaminase. Values were not determined on initial samples.

and had the greatest range in infestation levels. A significant ($P < 0.05$) natural logorithmic curve could be plotted to the data. At a ratio of 100% the predicted infestation level is very low (~4%), as would be expected, while at an infestation level of 15% the ratio is 65%. The curve indicates that even at low infestation levels (<15% of body surface), *P. ovis* had a marked effect on energy retention and maintenance energy requirements.

A multiple regression equation calculated from data of each of the calves gave the following equation:

$$ER = 17.3\,(MEI) - 0.872\,(INF) - 86.1\ (r^2 = 0.88)$$

in which ER is total energy retention in mcal, MEI is metabolizable energy intake in mcal day^{-1} and INF is the percentage of body surface infested with *P. ovis* on Week 7. If ER is set to 0 (i.e. maintenance) the equation can be used to calculate the maintenance energy requirement of calves with different *P. ovis* infestations. Using this equation it was calculated that maintenance energy requirements increased 0.5 mcal of ME day^{-1} for each 10% increase in the amount of body surface affected by *P. ovis* (Fig. 2).

Serum variables are presented in Table V. *P. ovis* infestation did not significantly affect serum urea-N or free fatty acids. Calves in the infested group had higher ($P < 0.05$) serum glutamic—oxaloacetic transaminase than control calves.

DISCUSSION

The *P. ovis* infestation levels noted in this study were similar to previous reports using similar techniques (Guillot, 1981; Guillot and Meleney, 1982), although they were more severe than infestations generally reported in calves that are able to groom (Guillot and Cole, 1984). Despite the severe *P. ovis* infestation, feed intake was not significantly depressed.

Low-feed-intake control calves lost about 0.07 kg of weight per day during the study while high-feed-intake control calves gained about 0.45 kg day^{-1}. Both values were about 0.1 kg less than the anticipated performance levels (NRC, 1984). High-feed-intake infested calves essentially maintained their weight even though their feed intake was almost twice that of low-feed-intake control calves. Fisher and Wright (1981) reported similar performance in *P. ovis*-infested bull and steer calves fed the same diet. Low-feed-intake infested calves lost almost 20 kg of weight during the trial. Because feed intakes were similar, weight gain differences resulted in significantly ($P < 0.05$) higher feed conversions (g weight gain kg^{-1} feed intake) in control calves compared to infested calves.

Although ration dry matter digestibility was not significantly affected by *P. ovis* infestation there was a trend toward a decreased digestibility in infested calves. This decline in digestibility is similar to that noted in calves during cold stress (Christopherson and Kennedy, 1983). Cold stress appears to reduce digestibility via an increase in the rate of passage through the digestive tract. This effect is apparently mediated by an increased secretion of thyroxine (Christopherson and Kennedy, 1983). Infested calves had reduced thermal insulation due to hair loss and damaged integument and thus were probably exposed to cold stress during the study. If energy digestibility was reduced similarly to DMD it would represent about a 2% decrease in the ME content of the diet.

As reported previously (Fisher and Crookshank, 1982) serum GOT was elevated in infested calves, suggesting that liver damage could have occurred. Unexpectedly, serum-free fatty acids, an indicator of adipose tissue catabolism, were not affected by *P. ovis* infestation. Serum samples were taken following an 18-h period without feed and water, therefore, any difference in free fatty acid due to feed intake or *P. ovis* infestation may have been undetectable at the sampling time used. Serum urea-N was higher in low-feed-intake calves than high-feed-intake calves even though they had lower total protein intakes. This difference suggests that low-feed-intake calves may have been catabolizing body tissue at the sampling time.

P. ovis infestation significantly reduced energy retention and increased maintenance energy requirements of calves in this study. The maintenance energy requirement of 78.3 kcal kg^{-1} MBW for control calves is very close to the value expected for normal calves (77 kcal kg^{-1} MBW, Lofgreen and Garrett, 1968). Maintenance requirements appeared to be increased even at low *P. ovis* infestation levels. Calf weight gains are generally not affected by *P. ovis* infestations of <15% of body surface (Fisher and Wright, 1981; Cole et al., 1984), however, it appears that utilization of feed energy, and thus feed conversion, is affected at low infestation levels. In minor infestations, calves may compensate for the higher energy requirement by increasing feed intake. In this way daily weight gains are maintained but gain:feed ratios are reduced. A similar response occurs in cattle subjected to cold stress (NRC, 1981).

The increase in maintenance energy requirement due to *P. ovis* infestation was not accounted for by a decrease in diet digestibility. It is also unlikely that an appreciable increase in either urinary energy excretions or ruminal methane production could account for the increased requirement since these losses account for only 5—15% of total energy intake (Blaxter and Clapperton, 1965; Blaxter et al., 1966). Both clinical infections (Long, 1977) and cold stress (Young, 1975) increase maintenance energy requirements. The calf with a *P. ovis* infestation may be especially compromised since the calf is suffering the stress of the mite infestation, as well as defending against topical microbial infections. The calf also has a loss of hair and integument damage which would increase the amount of energy required to maintain the body core temperature (NRC, 1981). The combination of these stress factors, therefore, can cause a significant increase in the maintenance energy requirement of calves, even when *P. ovis* infestations are low. Calves with severe *P. ovis* infestations may have difficulty in consuming sufficient amounts of feed to meet maintenance energy requirements and therefore may be highly susceptible to hypothermia.

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